

## CHAPTER CONTENTS

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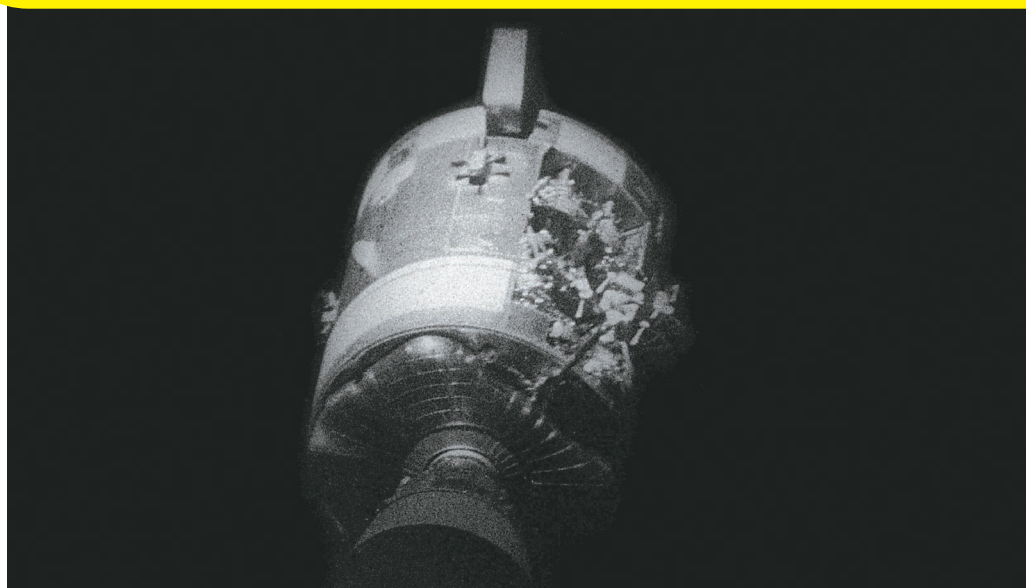
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- Centripetal acceleration



On April 13, 1970, almost 56 h and 333 000 km into their flight to the Moon, the crew of *Apollo 13* heard a loud bang and felt the spacecraft shudder. Astronaut Jack Swigert radioed NASA Ground Control: “Houston, we’ve had a problem here.” The above photograph, taken by the astronauts after they jettisoned the service module, shows how serious that problem was — an oxygen tank had exploded and damaged the only other oxygen tank. After assessing the situation, the astronauts climbed into the lunar landing module, where the oxygen and supplies were designed to support two people for two days. They would have to support the three astronauts for four days.

The spacecraft was still hurtling toward the Moon at more than 5000 km/h, and the engines of the lunar landing module could certainly not provide the force necessary to turn the craft back toward Earth. The only available force that could send the astronauts home was the gravitational force of the Moon, which swung the crippled spacecraft around behind the Moon and hurled it back toward Earth. With the engines of the lunar landing module, the crew made two small course corrections that prevented the craft from careening past Earth into deep space. Exactly 5 days, 22 h, and 54 min after lift-off, the astronauts, back inside the command module, landed in the Pacific Ocean, less than 800 m from the rescue ship.

In this chapter, you will learn about Newton’s law of universal gravitation and how it guides the motion of planets and satellites — and damaged spacecraft.